CHAPTER II

SAFETY APPROVED SUPPRESSIVE SHIELDS

2.1 INTRODUCTION

There are eight suppressive shield design groups that have been developed to various stages of definition. These shield groups are summarized in Table 2-1 and illustrated schematically in Fig. 2-1. Some of the shield group designs have been safety approved by the Department of Defense Explosives Safety Board; others are still in the criteria development and preliminary design stage. Two of the groups, Shield Group 6 and Shield Group 81-mm, have two versions (or adaptations), both of which have been safety approved. More detailed information on each of the eight shield group designs is presented in Tables A-1 through A-8 in Appendix A.

The five suppressive shield group designs approved by the Department of Defense Explosives Safety Board (Groups 3, 4, 5, 6 and 81-mm) have been designed to meet requirements for most applications to ammunition load, assembly, pack (LAP) in the Munitions Production Base Modernization and Expansion Program. However, specific shield requirements will vary with other applications and, even with LAP applications, design details will vary from plant to plant and between munitions or different operations on the line. It will, therefore, frequently be necessary to modify the approved shields to adapt them to the operation under consideration.

This chapter describes the safety approved shield group designs and provides guidance concerning acceptable modifications and recommended procedures for securing safety approval of new shield designs. Summary information on overall dimensions of the shield structure, charge capacity, rated overpressure, fragment stopping wall thickness, and type of construction of the five approved basic shield groups is included in Appendix A, Tables A-3 through A-6 and Table A-8.

Table 2-1

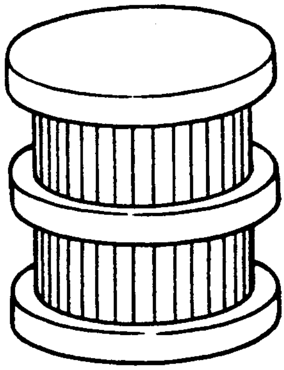
SUMMARY OF SUPPRESSIVE SHIELD GROUPS

Shield Group	Hazard Parameter		Representative Applications	Level of Protection*
	Blast	Fragmentation		
1	High	Severe	Porcupine Melter (2000 lbs) plus 2 pour units 250 lbs each	Reduce blast pressure at intraline distance** by 50%
2	High	Severe	HE bulk (750 lbs) Minute Melter	Reduce blast pressure at intraline distance** by 50%
3	High	Moderate	HE bulk (37 lbs) Detonators, fuzes	Category I hazard*** at 6.2 feet from shield
4	Medium	Severe	HE bulk (9 lbs) Processing rounds	Category I hazard*** at 19 feet from shield
5	Low	Light	30 lbs Illuminant Igniter slurry mixing HE processing (1.84 lbs)	Category I hazard*** at 3.7 feet from shield
6	Very High	Light	Laboratory, handling, and transportation	Category I hazard*** at 1 foot from shield
7	Medium	Moderate	Flame/fireball attenuation	Category I hazard*** at 5 feet from shield
81 mm	High	Moderate	81 mm mortar drill-and-face and/or cast-finishing operation	Category I hazard*** at 3 feet from shield

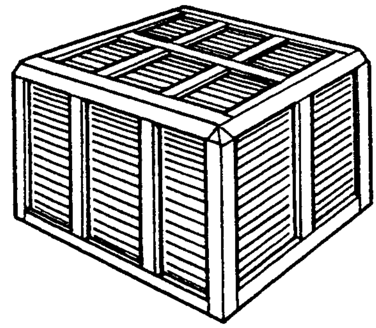
*All shield groups contain all fragments.

**Unbarricaded intraline distance as defined by Table 17-12, Ref. 2-1

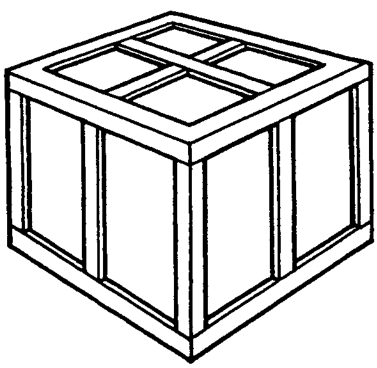
***Category I hazard (2.3 psi level) as defined by Ref. 2-3



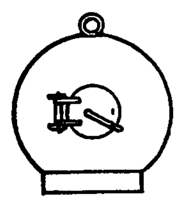
a. Suppressive Shield Groups 1, 2 and 3



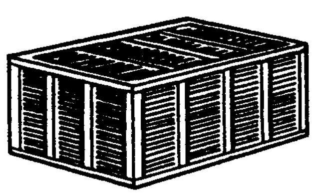
b. Suppressive Shield Group 4



c. Suppressive Shield Group 5



d. Suppressive Shield Group 6



e. Suppressive Shield Group 81-mm

Figure 2-1. General Configuration of Suppressive Shield Groups

Copies of the fabrication drawings for each approved shield design are included in Appendix A. Authorized agencies may attain full-size copies of the drawings from the Division Engineer, US Army Engineer Division, Huntsville, HNDED-CS, P. O. Box 1600, West Station, Huntsville, Alabama 35807.

2.2 SELECTION OF A SUPPRESSIVE SHIELD DESIGN

The procedure to follow in selecting an approved shield design for a particular application is outlined below. The same procedure would be followed for modification of an approved design or establishing the requirement for a new design.

2.2.1 Identify Hazardous Operations

The designer initially develops a facility concept, decides on the operations to be performed, and selects the equipment to be used. A hazard analysis is then performed to determine where protection from hazardous operations is required.

2.2.2 Determine Space Requirements

This step requires consideration of the size and shape of equipment and work space required inside the shield to estimate the approximate size and shape of the shield required. Space available for the operation on the line or in the building will also place limitations on overall shield base dimensions and height.

2.2.3 Determine Charge Parameters

Charge parameters which govern shield requirements are: charge weight (W), shape, confinement and composition; ratio of charge weight to shield internal volume (W/V); and scaled distance (Z) from the charge to nearest wall or roof of the shield ($Z = R/W^{1/3}$, where R is the distance from the center of the charge to the nearest wall or roof in feet and W is in pounds). Parameters for approved shield groups are summarized in Table 2-2. These charge parameters are used to determine the overpressure, impulse, and quasi-static overpressure loads on the suppressive structure. Calculations are typically made in terms of TNT equivalency. Determination of TNT equivalency is discussed in Chapter 3. A tabulation of conversion factors (Table 3-1) is presented there with guidance on how pressure and impulse for other types explosive are obtained.

Table 2-2

CHARGE PARAMETERS FOR SAFETY APPROVED SHIELDS

Shield Group	Min Z ($ft/lb^{1/3}$)		Max W/V (lb/ft^3)
	Wall	Roof	
3	1.63	1.45	0.04157
4	2.23	2.19	0.00762
5	4.14	6.79	0.00215
6A	1.01*	N/A	0.2297*
6B	1.22*	N/A	0.132*
Prototype 81 mm	3.62	3.21	0.0034
Milan 81 mm	4.23	3.75	0.0028

*Based on single equivalent charge

The shield selected for a given application must be approved for a design charge weight which equals or exceeds that of the application of interest. The internal dimensions of the shield must be such that the design charge-to-volume ratio (W/V) of the approved shield is not exceeded in the application. In addition, location of the charge must be such that the scaled distance Z in the application of interest is greater than or equal to the Z for the approved shield.

It may be possible in some cases to modify specific dimensions of a safety approved shield to accommodate a particular application. For example, it would be possible to increase the volume of a given shield design by increasing its length, which would reduce the W/V ratio (for the same charge weight) without altering the scaled distance Z to the nearest shield wall. A modification that would not be permitted without supporting engineering analyses to verify adequacy of shield strength would be to move the charge closer to a shield wall. This would decrease the scaled distance Z, even though the W/V ratio (for the same charge weight) might be greatly reduced by an increased length or height of the shield. Guidance concerning acceptable modifications to all safety approved shield groups is given in Appendix A.

2.2.4 Determine Fragment Parameters

Both primary and secondary fragment hazards and suppression must be considered. Classified Ref. 2-2 should be consulted to determine primary fragment hazards for standard ammunition. If this reference is not available, methods presented in Chapter 3 are used to determine primary fragment threats. Chapter 3 also describes methods for analysis of surrounding equipment to estimate secondary fragment hazards. Fragment hazards, interpreted in terms of a fragment perforation thickness from Chapter 3, are compared with the nominal wall thickness for the shield design being considered. Where a fragment perforation thickness exceeds the nominal wall thickness of the approved shield, the approved suppressive shield under consideration is inadequate and must be discarded for another shield with a larger nominal wall thickness.

2.2.5 Determine Specific Requirements of the Installation

After an approved suppressive shield has been selected and/or modified to meet space, explosive charge, and fragment conditions, the specific details of the installation such as environmental conditioning; product, access and conveyor doors; utility penetrations; and liners must be incorporated into the design. Recommended practices for the preparation of these design details in a manner that will not compromise safety of the installed shield are presented in Chapter 6.

2.3 APPROVAL OF NEW SUPPRESSIVE SHIELD DESIGNS

In some instances, none of the safety approved shield designs will be satisfactory for a particular application, even with permissible modifications to the design such as discussed above. In such cases, a suitable shield must be designed for the prescribed conditions utilizing the procedures and guidance contained in Chapters 3, 4, 5 and 6 of this handbook.

Any new design, or radical modification of an approved design, will require formal safety approval before the concept can be utilized in an operational installation. Obtaining safety approval for a suppressive shield design concept requires demonstrating conclusively that the design will accomplish its intended function. It may be possible in some cases to demonstrate the adequacy of a design analytically with the use of proven, accepted structural dynamic analysis procedures. If the adequacy cannot be proven analytically, proof-testing will be required. In such cases, the design concept is tested at 125 percent its rated design charge, i.e., a concept designed for 100 pounds of explosive would be tested with an actual charge of 125 pounds. Detailed requirements for planning, conducting and reporting the proof tests are presented in Ref. 2-3.

Safety approval is obtained by forwarding a Safety Approval Package through the safety chain of command. See Ref. 2-4 for samples of Safety Approval Documentation. Within the Department of the Army, this will require an approval by the Development and Readiness Command Safety Office and the Department of Defense Explosive Safety Board in addition to the internal reviews required by each subordinate command. The Safety Approval

Package describes the design concept; the analysis procedures and/or test operations employed to validate the concept; presents the analysis and/or test results; and evaluates and interprets the analysis/test results with respect to adequacy of the design concept. The documentation should also show, if appropriate, that this level at least equals the protection provided by existing explosives safety standards applicable in the absence of such engineered safeguards as suppressive shields or any other type of explosion-resistant construction.

2.4 SUPPRESSIVE SHIELD GROUP DESIGNS

Currently available safety approved shield designs range from units having about 4.2 cubic feet of interior volume weighing 165 pounds to assemblies with approximately 944 cubic feet of usable interior space weighing 45 tons. Preliminary design concepts are also complete for additional suppressive shield designs weighing up to 2880 tons with volumes to about 68,100 cubic feet and the capability for suppressing the hazardous effects from an accidental detonation of 2870 pounds of TNT. In general, as the size and weight of a suppressive shield increase, the charge weight that the shield is designed to suppress also increases. Appendix A contains design data for each shield group.

2.4.1 Shield Groups 1, 2 and 3

Shield Groups 1, 2 and 3 are scaled geometrically relative to each other. The Group 3 design has been safety approved. The Group 1 and 2 designs have not been safety approved and testing may be required for approval. The Group 1 shield is a very large structure measuring 45 ft in diameter and 52 ft in height externally. The blast environment is rated as high and the fragment hazard severe; see Table 2-1. The performance goals are to reduce blast pressure by 50 percent at the intraline distance as defined in Table 17-12 in Ref. 2-1 and to contain 100 percent of the fragments generated. The unbarricaded intraline distance can be approximated by $R = 18W^{1/3}$. The Group 1 shield can be applied at installations similar to a porcupine melt pour facility for which the concept has been developed.

The Group 2 shield design concept measures 34.3 ft in diameter and stands 33 ft tall externally. The blast environment is rated as high and the fragmentation hazard severe. Performance goals set for this group are to reduce the blast pressure by 50 percent at the intraline distance and to contain all fragments. The Group 2 shield would be appropriate for applications such as a minute melter (861 lb TNT equivalent).

The Group 3 shield, which was originally designed as a 1/4-scale Group 1 shield, stands 12.8 ft tall and measures 13.3 ft in diameter. Both dimensions are measured externally. The blast environment is again high, since all three groups (1, 2 and 3) are rated for the same internal blast pressure. However, the fragment hazard for the Group 3 shield is rated as moderate. The shield design has been tested and found to reduce the external pressure to 2.3 psi at a distance of 6.2 ft from the exterior of the shield. All fragments were contained by the shield. Also, the fireball was restricted to within four feet of the exterior wall. A typical application for the Group 3 shield would be for the high explosive incendiary (HEI) press operation in loading 20/30 mm HEI projectiles.

2.4.2 Shield Groups 4 and 5

Shield Groups 4 and 5 are depicted in Fig. 2-1 as rectangular parallelopipeds. The sizes of the two shields are similar, but the application and construction are different; both designs have been safety approved. The Group 4 shield measures 16.4 ft long by 11.5 ft wide by 10.4 ft high externally. The internal blast environment is rated as medium with a severe fragment hazard. Proof tests have shown that the external blast pressure is reduced to 2.3 psi at 19 feet from the external surface, all fragments are contained, and the fireball is restricted to within 10 ft of the exterior of the shield. A 105-mm high explosive projectile fuze-insert-and-torque operation would be a typical application for this shield group.

The Group 5 shield overall external dimensions are 12.6 ft square in plan and 9.2 ft high. The shield design blast environment is rated as low, and the fragment hazards associated with typical applications are light. Tests to verify the design adequacy indicate that external blast pressures are reduced to 2.3 psi at 3.7 ft from the exterior of the shield; the fireball extends two feet outside the shield; and all fragments are contained. The primary application for the Group 5 shield is operations involving propellants and pyrotechnics, i.e., an igniter slurry mixing operation.

2.4.3 Shield Group 6

The two similar designs of Shield Group 6 are both rated for very high blast loads and light fragment hazards. Both shield groups are spherical and measure nominally 24.5 inches in diameter externally. Both shields have been tested and safety approved. External pressures were reduced to less than 2.3 psi at a distance of 2 ft. All fragments were contained. Typical applications of these shield designs would be to safely transport or store small quantities of explosive, such as in a detonator loading facility or laboratory.

2.4.4 Shield Group 81-mm

The 81-mm shield group also has two approved designs. Both designs are rated for a high blast environment and a fragment hazard that is moderate. The original design, now referred to as the Prototype, measures 20 ft long x 15.4 ft wide x 13.1 ft high externally. Tests have demonstrated that blast pressures are reduced to 2.3 psi peak external pressure at three feet from any exterior shield wall; all fragments are contained within the shield; and the fireball is contained within the shield.

The adaptation of the Prototype 81-mm Shield design has been named Milan 81-mm and can be used in applications which do not require as much floor area as the Prototype 81-mm Shield and which involve smaller charge weights. The Milan 81-mm design measures 15.4 ft on a side and is 13.1 ft tall externally and was designed specifically for the 81-mm mortar projectile application to the fuze cavity facing operation on line "C" at Milan AAP. Predicted blast pressures are reduced to 2.3 psi at 7.3 ft from the external surfaces and no fragments perforate the shield walls.

Additional details on the safety approved suppressive shield designs are presented in Appendix A.

2.5 REFERENCES

2-1 Safety Manual, AMCR 385-100, U.S. Army Materiel Command, Alexandria, Va., Latest Edition. (U)

2-2 Joint Munitions Effectiveness Manual, FM101-62-3, Manual of Fragmentation Data, 15 September 1973. (C-XGDS-3)

2-3 Shields, Operational for Ammunition Operations, Criteria for Design of, and Tests for Acceptance, Mil Std 398, US Government Printing Office, Washington, D.C., 5 November 1976. (U)

2-4 Katsanis, D.J., Safety Approval of Suppressive Shields, EM-TR-76088, Edgewood Arsenal, Aberdeen Proving Ground, Md., August 1976. (U)